

WHAT IS CLAIMED IS:

1. A manufacturing method of an integrated capacitor,  
comprising:

forming a hole in a semiconductor substrate;

5 depositing a dielectric film on an inner face of the formed  
hole;

heat-treating the deposited dielectric film;

depositing a silicon film on the dielectric film;

10 embedding a resist film in the hole except an upper portion  
of the inner face of the hole on which the dielectric film and the  
silicon film are deposited;

etching the silicon film on the heat-treated dielectric film  
with the embedded resist film as a mask;

removing the resist film;

15 removing the heat-treated dielectric film by etching with  
the silicon film remaining after the etching as a mask; and

embedding an electrode material in the hole having the  
dielectric film remaining after the removal by etching.

2. A manufacturing method of an integrated capacitor as set  
20 forth in claim 1, wherein in the depositing the silicon film on the  
dielectric film, a polycrystalline silicon film or an amorphous  
silicon film is deposited as the silicon film.

3. A manufacturing method of an integrated capacitor as set  
forth in claim 1, wherein

25 in the embedding the resist film in the hole except the upper  
portion of the inner face of the hole on which the dielectric film  
and the silicon film are deposited, a novolak resin is used as the  
resist film, and

in the removing the resist film, the resist film is removed using a mixed solution of sulfuric acid and hydrogen peroxide aqueous solution.

4. A manufacturing method of an integrated capacitor as set forth in claim 1, wherein in the depositing the dielectric film on the inner face of the formed hole, an  $\text{Al}_2\text{O}_3$  film is used as the dielectric film and deposited by an ALD method.

5. A manufacturing method of an integrated capacitor as set forth in claim 4, wherein the heat-treating the deposited dielectric film is performed at a temperature of  $800^\circ\text{C}$  or higher.

6. A manufacturing method of an integrated capacitor as set forth in claim 1, wherein in the depositing the dielectric film on the inner face of the formed hole, as the dielectric film, a stacked film of an  $\text{Al}_2\text{O}_3$  film and a dielectric film other than the  $\text{Al}_2\text{O}_3$  film is deposited.

7. A manufacturing method of an integrated capacitor as set forth in claim 1, wherein the removing the heat-treated dielectric film by etching with the silicon film remaining after the etching as the mask, heated phosphoric acid is used as a chemical for the removal by etching.

8. A manufacturing method of an integrated capacitor as set forth in claim 1, wherein the silicon film remaining after the etching is left as a part of the electrode material to be embedded in the hole.

9. A manufacturing method of an integrated capacitor, comprising:

forming a hole in a semiconductor substrate;

depositing a dielectric film on an inner face of the formed

hole;

depositing a silicon film on the deposited dielectric film;

embedding a resist film in the hole except an upper portion  
of the inner face of the hole on which the dielectric film and the  
5 silicon film are deposited;

etching the silicon film on the deposited dielectric film  
with the embedded resist film as a mask;

removing the resist film, and removing the deposited  
dielectric film by etching with the silicon film remaining after  
10 the etching as a mask;

heat-treating the dielectric film remaining after the  
removal by etching; and

embedding an electrode material in the hole having the  
dielectric film remaining after the removal by etching.

15 10. A manufacturing method of an integrated capacitor as  
set forth in claim 9, wherein in the depositing the silicon film  
on the deposited dielectric film, a polycrystalline silicon film  
or an amorphous silicon film is deposited as the silicon film.

20 11. A manufacturing method of an integrated capacitor as  
set forth in claim 9, wherein

in the embedding the resist film in the hole except the upper  
portion of the inner face of the hole on which the dielectric film  
and the silicon film are deposited, a novolak resin is used as the  
resist film, and

25 in the removing the resist film and removing the deposited  
dielectric film by etching with the silicon film remaining after  
the etching as the mask, the resist film is removed using a mixed  
solution of sulfuric acid and hydrogen peroxide aqueous solution,

and the deposited dielectric film is removed by etching with the silicon film remaining after the etching as the mask.

12. A manufacturing method of an integrated capacitor as set forth in claim 9, wherein in the depositing the dielectric film on the inner face of the formed hole, an  $\text{Al}_2\text{O}_3$  film is used as the dielectric film and deposited by an ALD method.

13. A manufacturing method of an integrated capacitor as set forth in claim 12, wherein the heat-treating the dielectric film remaining after the removal by etching is performed at a temperature of  $800^\circ\text{C}$  or higher.

14. A manufacturing method of an integrated capacitor as set forth in claim 9, wherein in the depositing the dielectric film on the inner face of the formed hole, as the dielectric film, a stacked film of an  $\text{Al}_2\text{O}_3$  film and a dielectric film other than the  $\text{Al}_2\text{O}_3$  film is deposited.

15. A manufacturing method of an integrated capacitor as set forth in claim 14, wherein the dielectric film other than the  $\text{Al}_2\text{O}_3$  film is a  $\text{HfO}_2$  film.

16. A manufacturing method of an integrated capacitor as set forth in claim 9, wherein the silicon film remaining after the etching is left as a part of the electrode material to be embedded in the hole.

17. An integrated capacitor, comprising:

a semiconductor substrate;

a crystallized dielectric film which is formed on an inner face of a hole except an upper portion of the hole formed in the semiconductor substrate; and

an electrode material which is embedded in the hole.

18. An integrated capacitor as set forth in claim 17,  
wherein the crystallized dielectric film has  $\text{Al}_2\text{O}_3$  as its material.

19. An integrated capacitor as set forth in claim 17,  
wherein the crystallized dielectric film has  $\text{Al}_2\text{O}_3$  and a dielectric  
5 other than  $\text{Al}_2\text{O}_3$  as its materials.

20. An integrated capacitor as set forth in claim 19,  
wherein the dielectric other than  $\text{Al}_2\text{O}_3$  is  $\text{HfO}_2$ .